

Investment in transport infrastructure, transport induced-labor accessibility and industrial
productivity in ECOWAS region

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ABSTRACT

The ECOWAS region faces significant challenges in achieving industrial sector productivity, largely due to inadequate investment in transport infrastructure. This lack of investment has led to poor transport-induced labour accessibility, limiting the mobility of the workforce and access to employment opportunities. Insufficient public transportation options contribute to high transportation costs, long travel times, and reduced connectivity between urban and rural areas. These issues not only hinder the efficient movement of goods and services but also restrict the ability of workers to reach job markets, thereby impacting overall productivity and economic integration within the region. Therefore, this study examined the effect of investment in transport infrastructure and transport-induced labour accessibility on industrial sector productivity in ECOWAS countries. The study adapted an endogenous growth model to analyse data sets for fifteen ECOWAS countries spanning the years 1975 to 2024. Data was retrieved from the World Development Indicator (WDI) to estimate panel causality and cross-sectional autoregressive distributed lag (CS-ARDL) models. Findings showed that total investment in transport infrastructure and transport-induced labour accessibility had positive and significant effects on industrial sector productivity in both the short run and long run. Also, bidirectional causality was recorded among investment in transport infrastructure, transport-induced labour accessibility, and industrial sector productivity. Consequently, the government should invest in transport infrastructure and provide subsidies for public transport to enhance affordability and accessibility for workers, enabling them to commute to job locations despite poor road conditions.

Keywords: Transport Infrastructure, Industrial Sector Productivity, Transport-induced Labour Accessibility, Ross-sectional Autoregressive Distributed Lag (CS-ARDL), Panel data set

1. INTRODUCTION

An industrialized nation is expected to have appropriate infrastructure, as this will have a good impact on the industrial sector, which is viewed as a driving force for growth. The availability of adequate and efficient infrastructure not only improves the quality of

life of the people but also promotes rapid industrialization (Chukwuebuka & Jisike (2020). It was mentioned that increased transport infrastructure lowers travel expenses, which then affects how businesses and households behave in regard to where they are located within the transport network

(Michael 2021). Firms and families primarily use changes in proximity to economic activity to determine where they will be situated in the network. The interplay between improved transport infrastructure and spatial components results in economic gains, and the basic driver for additional benefits is these spatial shifts (Venables et al., 2014). For instance, in order to save on travel expenses, households are likely to be positioned closer to work. As a result of enhanced transport infrastructure, workers use input factors in manufacturing with higher productivity. Workers' productivity in terms of interacting with others and looking for resources is accelerated by improved transport infrastructure since it makes them more mobile. Businesses can identify workers on the labour market who are more suited to their needs through enhanced transport infrastructure. Investment in transport infrastructure is a key strategy for enhancing industrial sector productivity in the Economic Community of West African States (ECOWAS). By improving labour accessibility and reducing transaction costs, these investments can support the region's economic integration and development goals.

The accessibility of skilled labour to industrial sector productivity is largely dependent on the smooth operation of transportation sectors. The status of the transport infrastructure connecting residential regions to industrial zones is a significant

determinant of this accessibility. Inadequate or poorly connected transportation networks can limit access to job opportunities. Limited connectivity can lead to a lack of job options, hindering the ability of workers to access employment opportunities and potentially contributing to unemployment or underemployment. Congested road networks can result in significant delays and increase commuting times. Prolonged commuting times reduce the attractiveness of distant job locations, affecting the willingness of workers to travel long distances. This can also lead to increased stress and fatigue among employees. Poor road conditions can lead to increased vehicle maintenance costs, longer travel times, and potential safety hazards such as accidents, vehicle damage, and injuries. Poor road conditions discourage workers from commuting longer distances for employment. The delicate interplay among investment in transport infrastructure, labour accessibility, and industrial sector productivity is a complex issue that requires extensive research.

ECOWAS has diverse economic structures and varying levels of infrastructure development. Historically, the region's transport infrastructure has been underdeveloped, with many countries facing challenges such as poor road conditions, limited rail networks, and insufficient port facilities. This situation has impeded intra-regional trade and limited the potential for economic growth. Many ECOWAS countries

still face significant infrastructure deficits, with inadequate road, rail, and port facilities. This limits the full potential of transport-induced productivity gains. Financing large-scale infrastructure projects remains a major challenge. The reliance on foreign aid and loans can create dependencies and financial vulnerabilities. Effective infrastructure development requires coordination across multiple jurisdictions and sectors. In ECOWAS, differing national priorities and regulatory environments can complicate regional infrastructure projects.

2 Literature review

Several studies have delved into the argument of transport infrastructure and level of productivity in regional and single country issues. However, inconclusive results revolve around a positive or negative relationship between the two. Piyapong (2023) was one of the studies that examined the effects of transport infrastructure investment in local employment and manufacturing companies in the United States. The study employed panel data for 48 nearby US states and country-level panel data for the state of North Carolina to evaluate the link between time and location using dynamic panel and spatial econometric techniques. According to the research, adding more lanes to major intrastate highways can boost the growth of the service sector's employment while delaying that of the manufacturing sector. However, the study found a causal relationship between the rapid

expansion of roads, employment, and the slowing down of manufacturing sectors, which led to an increase in the volume of the main non-interstate roadway.

Demetriades and Mamuneas (2022) also examined how public infrastructure investments affected employment and industrial sector productivity in 12 OECD economies. Co-integration analysis was used in the inquiry for the study. The research found that in all 12 countries, the growth of public infrastructure had an impact on industrial sector productivity, supply, and input demand both immediately and later on. As opposed to the long-run rate, which is substantial but steadily dropping, the short-run rate effect is comparatively low. These statistics showed that in the 1970s and 1980s, there was a serious underinvestment in infrastructure, which was eventually closed in the early 1990s, which spurred industrial sector performance.

Bimba et al. (2020) investigated from 1981 to 2016 how China's industrialization was affected by public infrastructure spending. The variables' order of integration was determined by the study's use of the Augmented Dickey-Fuller statistics (ADF) impulse response function, and the results of the variance decomposition were validated. The conclusion shows that infrastructure spending affects industrial production over a longer period of time. The outcome

demonstrates that China's industrialization and public infrastructure development are positively and significantly related. Khalid et al. (2020) studied the relationship between Pakistan's industrial output and investment in transport infrastructure. The study looked at how Pakistan's industrial output was impacted by several types of transport infrastructure, including roads, trains, ports, and airports. The findings showed that all the relevant variables exhibit an equilibrium relationship over the long term. Pakistan's industrial output is driven by its infrastructure, including its ports, highways, and labour force. Long-term elasticities predict that a 1% improvement in port and road infrastructure will increase industrial value added by 0.36% and 0.28%, respectively. They found that, whereas airways had no obvious effect, insufficient railways hindered industrial output.

The impact of newly built highways on employment and transport-induced labour productivity in Britain was analysed by Stephen et al. (2019) using data from industrial firms. The road network was employed as a proxy for exposure to transportation improvements in the study to estimate changes in the minimum time required for labour to go from home to work. The study discovered a strong positive relationship between freshly built roadways, employment, and neighbourhood businesses. According to the findings, newly built

highways draw and recruit transportation-intensive firms to the area. This leads some already-established companies to restructure their production processes. Na et al. (2011) investigated how roads affected labour market activity in 19 OECD nations. The study used several models that included dependent, independent, and control variables during a period of 17 years, from 1990 to 2006. According to the study, the network effect of highways will enhance labour productivity per worker. According to the findings of 19 OECD nations, there is a correlation between highway use and employment activity.

The effect of road infrastructure and labour accessibility on manufacturing sectors in Mexico was examined by Castaeda and Shemesh (2000). The study, which covered the 25-year period from 1993 to 2018, used an autoregressive distributed lag (ARDL). It found that a 10% increase in labour accessibility will increase manufacturing productivity by 0.62% to 0.96%; the immediate effect may be small, but the long-term impact will be greater. However, Leopoldo and Daniel (2013) examined the effects of road infrastructure on employment productivity and growth: An empirical analysis at ECOWAS from the period of 1991–2011. The study used dynamic panel GMM system estimation. The findings (using parametric and non-parametric estimations) show that road density and road paving have positive effects on total factor productivity

(TFP) in countries with low and middle incomes. When taking the percentage of paved roads into account, the analysis discovered empirical evidence of the Kuznets curve. Additionally, the study discovered a Kuznets curve between road density and unemployment in nations with middle and low income levels.

3 Research methods and procedure

In analysing the impact of investment in transport infrastructure and transport induced-labour accessibility on industrial productivity in the ECOWAS region, this study is grounded in endogenous growth theory. This theory suggests that advancements in innovation, knowledge, and human capital drive productivity enhancements, which in turn stimulate economic growth. Building on the framework established by Mankiw, Romer, and Weil (1992), the model is formulated as follows:

$$Y(t) = K(t)^\alpha A(t)L(t)^{1-\alpha} \quad (1)$$

Where Y_i is the output, K_i is the capital, L_i is the Labour and A is the level of technological progress.

$$K(t)^* = \left(\frac{S}{\delta}\right)^{\frac{1}{1-\alpha}} A(t)L(t) \quad (2)$$

Note that K , A and L are function of time, and S , δ and α are all constants, $L(t)$ is the labour force with growth at rate n and $A(t)$ is the technology growth at rate g .

$$y(t)^* \left(\frac{S}{\delta}\right)^{\frac{\alpha}{1-\alpha}} A(t)L(t) \quad (3)$$

The below equation is the output per labour, which is replaced with the growth of the economic sector (GES), and this serves as the foundation for the theoretical framework underpinning this study.

$$gy = g + n \quad (4)$$

Expanding the theoretical framework to explore the dynamic relationship between investments in transport infrastructure, transport induced-labour accessibility and industrial sector productivity within the Economic Community of West African States (ECOWAS), this study builds upon the model previously utilised by Chukwuebuka and Jisike (2020). In this model, the independent variable is the level of transport infrastructure (TI_{it}), while the dependent variable is the value added by the industrial sector ($INDV_{it}$) at time t . The functional form of the model is expressed as follows:

$$INDV_{it} = f(TI_{it}) \quad (5)$$

In expanding transport infrastructure, total investments in transport infrastructure and transport induced-labour accessibility were examined in terms of industrial sector productivity.

$$INDV_{it} = f(TITI_{it}; TILA_{it}; V_{it}) \quad (6)$$

In equation 6, industrial sector productivity ($INDV_{it}$) was measured using data on industry value added, following the methodologies of Chen and Golley (2014), Chenery (1960), and Sveikauskas, Rowe, Mildemberger, Price, and Young (2018). Investment in transport infrastructure ($TITI_{it}$) was quantified by the total investment in

transport infrastructure with private participation. The transport induced-labour accessibility ($TILA_{it}$) was calculated by using labour force divided by total investment in transport infrastructure and V_{it} represents a vector of control variables, which includes: Gross capital formation (GCF_{it}), labour force participation rate (LF_{it}) credit to the private sector ($CRED_{it}$) and defence budget (DB_{it}). These control variables are in line with those used by Chukwuebuka and Jisike (2020) and Azolibe and Okonkwo (2020).

Model 1:

$$\begin{aligned}
 &INDV_{it} \\
 &= f(TITI_{it}; TILA_{it}; GCF_{it}; LF_{it}; CRED_{it}; DB_{it})
 \end{aligned}
 \tag{7}$$

Model 1 explores how investment in transport infrastructure, transport induced-labour accessibility and other control variables influence industrial sector productivity. The semi-log-linear form of the model is specified as follows:

$$\begin{aligned}
 InINDV_{it} = &\beta_0 + \beta_1 InTITI_{it} \\
 &+ \beta_2 TILA_{it} + \beta_3 InGCF_{it} \\
 &+ \beta_4 LF_{it} + \beta_5 CRED_{it} + \beta_6 DB_{it} \\
 &+ \mu_{it}
 \end{aligned}
 \tag{8}$$

Where: $InINDV_{it}$ is the natural log of industrial value added for country i in period t . In $TITI_{it}$ is the natural log of total investment in transport infrastructure for country i in period t . $InTILA_{it}$ denotes transport-induced labour accessibility, which is measured by calculating the transport-induced labour accessibility indicator of the integral index. This integral indicator reflects

the total transport costs and is calculated using the $Transport - induced\ Labour\ accessibility_{it} = \sum_k LF_{it} / InTITI_{it}$

Where $Transport - induced\ Labour\ accessibility_{it}$ is defined as LAB_{it} is the total labour force of country i over period t ; $InTITI_{it}$ is log of total investment in transport infrastructure (Lee 2019 and lavrinenko et al., 2019). $InGCF$ is the natural log of gross capital formation for country i in period t . LF_{it} represents the labour force participation rate, defined as the percentage of the total population aged 15 and above that is actively engaged in the labour market. It serves as a proxy for the availability of vibrant and skilled labour crucial for industrial production. $CRED_{it}$ is the ratio of credit to the private sector to GDP for country i in period t . As defined by Olowofeso et al. (2015), this includes financial resources provided to the private sector, such as loans, advances, purchases of non-equity securities, trade credits, and other accounts receivable that establish a claim for repayment. Adequate credit to the industrial sectors enhances investment levels and productivity. DB_{it} is the ratio of government expenditure on defence to GDP for country i in period t . Government spending on defense helps create a secure environment free from internal and external threats, promoting

business activities and ensuring the safety of investments, which in turn boosts industrial productivity is the ratio of government expenditure on defense to GDP for country i in period t . Government spending on defence helps create a secure environment free from internal and external threats, promoting business activities and ensuring the safety of investments, which in turn boosts industrial productivity. μ_{it} is the error term. This model helps in understanding how changes in investment in transport infrastructure, along with other economic factors, impact the productivity of the industrial sector in different countries over time.

Model 2

The second objective identified the direction of causality among the investment in transport infrastructure, transport-induced labour accessibility, and industrial productivity in the ECOWAS region. The Granger causality test was utilised to achieve this objective. Hurlin's (2005) panel causality test also necessitates covariance-stationary variables for the variables being examined. Granger (1969) permits testing of the causal links between variables after the stationarity of the variables has been established. The Panel Granger causality test, which integrates cross-sectional and time-series data, is a better technique for determining causality than the well-developed Granger causality test for time-series data. Compared to using solely time-series data, it

is more efficient (Hurlin & Venet, 2001). In 1988, Holtz-Eakin, Newey, and Rosen created the Panel Granger test. They take into account the subsequent fixed-effect model: In this study, attempts were made to determine whether investment in transport infrastructure and transport-induced labour accessibility influence industrial sector productivity in ECOWAS or vice versa. Thus, the model is specified as:

$$\ln INDV_{it} = \beta_{1i} + \sum_{k=1}^k \partial_{11i} \ln INDV_{it-1} + \sum_{k=1}^k \partial_{12i} \ln TITI_{it-1} + \sum_{k=1}^k \partial_{13i} \ln TILA_{it-1} + \varepsilon_{1t} \quad (9)$$

$$\ln TITI_{it} = \beta_{2i} + \sum_{k=1}^k \partial_{21i} \ln TITI_{it-1} + \sum_{k=1}^k \partial_{22i} \ln INDV_{it-1} + \sum_{k=1}^k \partial_{23i} \ln TILA_{it-1} + \varepsilon_{2t} \quad (10)$$

$$\ln TILA_{it} = \beta_{3i} + \sum_{k=1}^k \partial_{31i} \ln TILA_{it-1} + \sum_{k=1}^k \partial_{32i} \ln INDV_{it-1} + \sum_{k=1}^k \partial_{33i} \ln TITI_{it-1} + \varepsilon_{3t} \quad (11)$$

$\ln INDV_{it}$, $\ln TITI_{it}$ and $\ln TILA_{it}$ represent industrial sector productivity, total investment in transport infrastructure, and transport-induced labour accessibility for country i at time t , respectively. ε_{it} represents the error term, which is assumed to be serially uncorrelated and have zero mean. Additionally, β_{1i} represents the constant drifts. These equations (9, 10, and 11) form a system of simultaneous equations that facilitates testing Granger causality within a panel data framework. This setup helps to understand the causal relationships between industrial sector productivity, investment in transport infrastructure, and transport-induced

labour accessibility across the selected countries over time.

3.2 Data description

Panel data from all fifteen (15) ECOWAS members was employed in this study. Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo are the nations that make up the ECOWAS. The choice of ECOWAS countries was due to a lack of infrastructure and a decline in industrial sector productivity. Many ECOWAS nations are classified as low- and middle-income countries.

Abbreviation	Description	Measurement	Source
<i>INDV</i>	Industrial sector productivity	Industry Value Added	World Development Indicator (WDI), 2024
<i>TITI</i>	Investment in transport infrastructure	Total investment in transport with public private participation	World Development Indicator (WDI), 2024
<i>TILA</i>	Transport-induced labour accessibility	$Labour\ accessibility_j = \sum_k LF_{it} / TITI_{it}$ (Lee 2019, and lavrinenko et al 2019).	Transport-induced labour accessibility $TILA_{it}$ was calculated by using labour force to divide total investment in transport infrastructure from (WDI) (Lee 2019, and lavrinenko et al 2019).
<i>GCF</i>	Gross capital formation	The stock of private capital used in the production at annual percentage growth rate	World Development Indicator (WDI), 2024
<i>LAB</i>	Labour	Total labour force participation rate (percentage of people from 15 to 65 years old)	World Development Indicator (WDI), 2024
<i>CRED</i>	Credit to private sector	Credit to the private sector as a percentage of GDP	World Development Indicator (WDI), 2024
<i>DB</i>	Defense Budget	The ratio of government defense budget to GDP	World Development Indicator (WDI), 2024

The World Bank Development Indicators (WDI) of numerous topics up to 2024 was used to generate panel data for the study, which spans the years 1975 through 2024

3.3 Estimation Technique

This study used three techniques to analyse the impact of transport infrastructure on industrial productivity in ECOWAS countries. First, we examined the data using descriptive statistics. This involved

calculating averages and using tests like Jarque-Bera to check if the data followed a normal distribution (Gujarati & Dawn, 2009). Also, we performed correlation analyses to avoid issues with multicollinearity (when variables are highly correlated). The study

then employed panel unit root tests to see if the data had a time trend (was increasing or decreasing over time). The factor-based technique was chosen because it can handle scenarios in which the economies of different countries are intertwined. These tests looked at second-generation tests to investigate whether all the variables influence each other. Finally, we applied a specific model called the Cross-sectional Augmented Autoregressive Distributed Lag (CS-ARDL) model. This model was used to predict how changes in transport infrastructure would affect industrial productivity across the 15 ECOWAS countries. To assess the accuracy of the model's predictions, the root mean square error (RMSE) was estimated. A lower RMSE indicates a more effective model.

4 Results

Table 2 provides descriptive statistics, including the mean, maximum, minimum, standard deviation, skewness, kurtosis, Jacque-Bera statistic, and number of observations for various variables. These variables encompass the dependent variable, Industrial sector productivity (*INDVA*), as well as independent variables such as total investment in transport infrastructure (*TITI*) and transport-induced labour accessibility (*TILA*). Additionally, control variables including gross capital formation (*GCF*), labour force participation rate (*LAB*), credit to the private sector (*CRED*), and defence budget (*DB*) are included. These statistics cover data from all fifteen (15) ECOWAS nations spanning the period from 1975 to 2024.

Table 2: Summary Statistics of Variables

Variables	INDVA	TITI	TILA	LF	GCF	CRED	DB
Mean	38.0143	19.8703	0.0191	49.6165	54.5874	14.6325	1.7411
Maximum	253.7166	296.5093	0.1285	79.2900	515.6162	73.1921	29.7277
Minimum	3.4067	0.0145	0.0017	23.8550	5.3539	0.0000	0.0087
Std. Dev.	36.4500	39.8103	0.0184	13.5441	83.8012	11.3264	2.8718
Skewness	2.6316	3.3979	2.6414	0.0649	3.4774	1.8238	6.6188
Kurtosis	11.4404	16.0032	11.5187	2.0884	15.8314	7.8719	50.9641
Jarque-Bera	2906.4070	6323.3980	2951.4890	24.9038	6256.8470	1088.0510	72726.3100
Obs	705	705	705	705	705	705	705

Source: Author's Computation, 2024

Note: Std. Dev.= Standard Deviation, and Obs=number of Observations. The bolded values implies significance at 5%.

INDVA: Industrial sector productivity has a mean value of 38.014 with a standard deviation of 36.450. **TITI;** Investment in transport infrastructure has a mean value of 19.870 with a standard deviation of 39.810.

TILA; Transport-induced labour accessibility has a mean value of 0.0191 with a standard deviation of 0.0184. According to the mean value, the ECOWAS's industrial sector productivity, transportation infrastructure

investment, and labour accessibility caused by transportation increased at average rates of 38.014, 19.870, and 0.019 between 1975 and 2024. The ECOWAS member countries exhibit varying levels of productivity in the industrial sector, investment in transportation infrastructure, and labour accessibility influenced by transportation, as demonstrated by the minimum and highest values.

Skewness values are positive for all variables while kurtosis values exceeding 3 suggest

Table 3 presented the correlation matrix coefficients of the dependent variable, Industrial sector productivity (*INDVA*); independent variables, namely total investment in transport infrastructure development (*TITI*), transport-induced labour accessibility (*TILA*) and the control variables such as gross capital formation(*GCF*), labour force participation rate (*LAB*), credit to private sector (*CRED*), and defence spending (*DB*) for all the fifteen (15) ECOWAS nations from the period between 1975 and 2024.

The correlation among the covariate regressors is also established using the reported individual coefficient of each variable. Evidently, there is an absence of perfect correlation among the covariate regressors since the correlation matrix coefficients ranged from -0.7100 to 0.2165, which is less than 0.90. Therefore, this suggests the absence of multicollinearity among the regressors in the study.

Table 3: Results of Correlation Matrix Coefficients

	INDVA	TITI	TILA	GCF	LF	CRED	DB
INDVA	1.0000						
TITI	0.0961	1.0000					
TILA	0.2165	-0.7100	1.0000				
GCF	0.1469	0.1294	-0.0231	1.0000			
LF	0.0723	-0.0291	-0.0597	-0.0440	1.0000		
CRED	-0.0609	0.0310	-0.1005	-0.2947	-0.2453	1.0000	
DB	-0.1116	-0.0520	-0.0644	0.1337	0.1205	-0.1395	1.0000

Source: Author’s Computation, 2024

leptokurtic distributions for all variables except for labour force, which exhibit platykurtic distributions (kurtosis values below 3). Jarque-Bera statistics indicate that all series are not normally distributed, with statistically significant p-values at a 5% level, rejecting the normality assumption. Therefore, the variables do not follow a normal distribution over the period studied.

A cross-sectional dependence test presented in Table 4 was estimated before estimating the model for the link between total investment in transport infrastructure, transport-induced labour accessibility, and industrial sector productivity in ECOWAS. Cross-sectional dependence is a common statistical attribute of panel datasets, often

driven by unified economic policies and financial and economic integration among countries, particularly within regions like ECOWAS. Therefore, testing for cross-sectional dependence in the variables is essential to determining the appropriate techniques for examining their relationships.

Table 4 : Cross-sectional Dependence tests

Variables	Bruesch-Pagan LM	Pesaran LM	Scaled	Bias-corrected scaled LM	Pesaran CD
<i>IND_{VAL}</i>	2150.1640***	141.1297***		140.9667***	31.7376***
<i>TITI</i>	1927.4470***	125.7608***		125.5977***	21.0501***
<i>TILA</i>	2534.5840***	167.6573***		167.4942***	26.1733***
<i>GCF</i>	1378.7750***	87.8988***		87.7358***	28.9727***
<i>LAB</i>	2391.1200***	157.7573***		157.5942***	17.0657***
<i>CRED</i>	1386.2230***	88.4128***		88.2497***	22.2571***
<i>DB</i>	1058.5840***	65.8035***		65.6405***	0.1571

Source: Author's Computation, 2024

Note: *** represents statistical significance at 1%.

To ensure robustness, the study applied four widely recognised cross-sectional dependency tests to determine the level of dependency among the ECOWAS countries: the Breusch-Pagan LM test, the Pesaran Scaled LM test, the Bias-corrected Scaled LM tests, and the Pesaran Cross-sectional Dependence (PCD) test. The results of these tests, presented in Table 3, provide strong evidence of cross-sectional dependence for all variables, with statistical significance mostly at the 1 percent level. This finding indicates that cross-sectional dependence is a critical factor to account for in the analysis.

Further pre-test analysis was conducted to identify the variables' orders of integration

(see Table 5). To verify that the series used in the analysis were stationary, a unit root test was conducted. In particular, it used robust second-generation unit root tests against cross-sectional dependence in panel data, such as the cross-sectional augmented Dickey-Fuller (CADF) test and the cross-sectional augmented Im, Pesaran, and Shin (CIPS) test. The results of the second-generation unit root tests show that the variables have a mixed order of integration. Thus, the model that is most suitable for this study is the Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) model, which is strong enough to handle mixed order of integration and robust to cross-sectional dependence in panel data.

Table 5 Panel Unit Root Tests

Variables	Level	CIPS		Level	CADF	
		1 st Difference	Integ. Order		1 st Difference	Integration order
INDVA	-2.5230***	-6.0360***	<i>I</i> (0)	-1.9850	-2.6800***	<i>I</i> (1)
TITI	-2.8340***	-5.9570***	<i>I</i> (0)	-1.4410	-3.0190***	<i>I</i> (1)
TILA	-1.6320	-5.8790***	<i>I</i> (1)	-0.7470	-2.4490***	<i>I</i> (1)
GCF	-2.9000***	-5.6370***	<i>I</i> (0)	-1.8130	-2.8900***	<i>I</i> (1)
LF	-1.5480	-2.5050***	<i>I</i> (1)	-0.5740	-3.4280***	<i>I</i> (1)
CRED	-1.6740	-5.8090***	<i>I</i> (1)	-1.4250	-2.9410***	<i>I</i> (1)
DB	-2.2650***	-5.6640***	<i>I</i> (0)	-1.2940	-2.2380**	<i>I</i> (1)

Source: Author's Computation, 2024

Note: *** $p < 0.01$ and ** $p < 0.05$; Critical values: -2.03, -2.11, -2.26 for 10%, 5%, and 1% significance level respectively. **Footnote:** CIPS Cross-sectional augmented Im, Pesaran, and Shin and CADF Cross-sectional Augmented Dickey-Fuller

This study used second-generation (Westerlund) cointegration tests to evaluate the possibility of cointegration among variables with varied orders of integration. Taking into account any potential cross-sectional dependence among the variables, these tests were selected to look into the existence of a cointegrating relationship. Four indicators were used to confirm cointegrating variables. The Pedroni residual cointegration test results show significant cointegration estimates across seven statistics from the panel and group strands. This validates the study's conclusion that the variables are cointegrated. A statistically significant t-statistic of -6.3217 was also obtained at the

1% level using the Kao residual cointegration test, which further supported the existence of a cointegrating relationship between the variables. In addition to the first-generation tests, the Westerlund cointegration test results show that all four statistics are statistically significant, indicating robust evidence of cointegration among the variables. This comprehensive analysis supports the examination of relationships involving total investment in transport infrastructure, transport-induced labour accessibility and industrial productivity across ECOWAS nations. These findings are detailed in Table 6, providing robust evidence of cointegration among the variables examined.

Table 6: Panel Cointegration Tests

Panel A: Pedroni Residual Cointegration Test			
Panel Statistics		Group Statistics	
Panel v-Statistics	0.9557(0.1696)	Group rho-Statistic	-0.0336(0.4866)
Panel rho-Statistic	-0.7408(0.2294)	Group PP-Statistic	-2.3569*** (0.0092)
Panel PP-Statistic	-2.5362*** (0.0056)	Group ADF-Statistic	-1.5867* (0.0563)
Panel ADF-Statistic	-2.0608** (0.0197)		
Panel B: Kao Residual Cointegration Test			
t-Statistic	-6.3217*** (0.0000)		

Residual Variance 69.1233

HAC Variance 84.5658

Panel C: Westerlund Cointegration test

G_t	-2.8780** (0.0400)	P_t	-13.3480*** (0.0000)
G_a	-13.6870** (0.0300)	P_a	-14.7300*** (0.0000)

Source: Authors' Computation, 2024

Note: Values in the parentheses denote probability values. ***, **, and * represents statistical significance at 1%, 5%, and 10%, respectively.

Table 7 presents the findings from the Cross-sectional Autoregressive Distributed Lag (CS-ARDL) technique. This technique was chosen due to the presence of cointegration, non-

stationarity, and cross-sectional dependence in the series. Additionally, to evaluate causality, the panel causality test by Dumitrescu and Hurlin (2012) was utilised.

Table 7: Result of Effects of Investment in Transport Infrastructure on Industrial Sector Productivity in ECOWAS

Dependent variable: <i>INDVA</i>				
Panel A: Long-run Estimates				
Variable	Coefficient	Std. Error	t-Stat	Probability
<i>TITI</i>	1.8637**	0.9461	1.97	0.049
<i>TILA</i>	1997.46***	1.5616	1279.16	0.000
<i>GCF</i>	0.1793	0.1018	1.76	0.078
<i>LF</i>	-0.4010	1.0452	-0.38	0.701
<i>CRED</i>	-0.0119	0.1232	-0.10	0.923
<i>DB</i>	1.2463**	0.5522	2.26	0.024
Panel B: Short-run Estimates				
Variable	Coefficient	Std. Error	t-Stat	Probability
$\Delta INDVA$	0.0251	0.0425	0.59	0.555
$\Delta TITI$	1.7669**	0.8944	1.98	0.048
$\Delta TILA$	1996.13***	1.5310	1303.78	0.000
ΔGCF	0.1771	0.1018	1.74	0.082
ΔLF	-0.3237	0.9757	-0.33	0.740
$\Delta CRED$	-0.0425	0.1191	-0.36	0.721
ΔDB	1.2815**	0.5181	2.47	0.013
ECM_{t-1}	-0.9749***	0.0425	-22.94	0.000
Panel C: Diagnostic test		Statistic	Prob	
RMSE		2.28	0.0000	

Source: Author's Computation, 2024

Note: ***, **, and * represents statistical significance at 1%, 5%, and 10%, respectively.

According to the findings in Panel A, there is evidence indicating that investment in transport infrastructure, transport-induced labour accessibility and defence spending

exert positive and significant effects on industrial sector productivity in ECOWAS over the long term. (*TITI* = 1.8637, t-stat = 1.97, $p < 0.05$; *TILA* = 1997.468, t = 1279.16,

$p < 0.0$ and $DB = 1.2463$, $t\text{-stat} = 2.26$, $p < 0.05$). This implied that investment in transport infrastructure, transport-induced labour accessibility and defence spending were significant factors influencing changes in the industrial sector in ECOWAS in the long run. Conversely, the labour force participation rate and credit to the private sector does not significantly respond to changes in industrial sector productivity in the ECOWAS region over the long term. Moreover, the magnitudes of the estimated parameters indicate that a 1 percent increase in investment in transport infrastructure results in a 1.8637 percent increase in industrial sector productivity. Additionally, a unit increase in transport-induced labour accessibility and defence spending corresponds to 199.75 and 124.63 percent increase in industrial sector productivity respectively, in ECOWAS over the long term.

Based on the short-run estimates, it is evident that investment in transport infrastructure, transport-induced labour accessibility and defence spending are positive and statistically significant. ($TITI = 1.7669$, $t\text{-stat} = 1.98$, $p < 0.05$; $TILA = 1996.132$, $t = 1303.78$, $p < 0.05$ and $DB = 1.2815$, $t\text{-stat} = 2.47$, $p < 0.05$) on industrial sector productivity in ECOWAS. Conversely, the labour force participation rate and credit to the private sector does not significantly respond to changes in industrial

sector productivity in the ECOWAS over the short term. This suggests that the relationship between the variables remains consistent over both short-run and long-run periods.

The ECT, denoted as ECM_{t-1} , indicates how quickly variables adjust to shocks and return to their equilibrium levels. Typically, a negative coefficient of ECM_{t-1} , with an absolute value less than one and statistically significant at a chosen significance level, is expected. The coefficient of the error correction term ($ECM_{t-1} = -0.9749$, $t\text{-stat} = -22.94$, $p < 0.05$) was estimated to be negative and statistically significant at the 1 percent level. This suggested that by next year, deviations from the industrial productivity equilibrium trend will be adjusted by roughly 97 percent. In summary, from 1975 to 2024, the industrial productivity adjustment process is moving quickly. Moreover, the results of the cointegration tests presented in Table 6 are supported by the importance of the error correction term coefficient, which validates the existence of a long-run equilibrium relationship in the model estimated for investment in transport infrastructure and industrial productivity. The results indicated that the root mean square error (RMSE) of 2.28 is relatively low; suggesting that the estimated model effectively elucidates the relationship between investment in transport infrastructure and industrial sector productivity in ECOWAS.

Table 8: The result of direction of causality among investment in transport infrastructure, total road network, and industrial Sector productivity in ECOWAS

	W-stat	Prob	Remarks
A: Total Investment in Transport Infrastructure and Industrial Sector Productivity			
<i>TITI</i> \Rightarrow <i>INDVA</i>	4.4642***	0.0000	
<i>INDVA</i> \Rightarrow <i>TITI</i>	5.2722***	0.0000	Bidirectional causality
B: Transport-Induced Labour Accessibility and Industrial Sector Productivity			
<i>TILA</i> \Rightarrow <i>INDVA</i>	4.3697***	0.0000	
<i>INDVA</i> \Rightarrow <i>TILA</i>	5.2398***	0.0000	Bidirectional causality
C: : Transport-Induced Labour Accessibility and Total Investment in Transport Infrastructure			
<i>TILA</i> \Rightarrow <i>TITI</i>	3.2596**	0.0439	
<i>TITI</i> \Rightarrow <i>TILA</i>	3.4542**	0.0186	Bidirectional causality

Source: Author's Computation, 2023

Note: *** and ** represents statistical significance at 1% and 5%, respectively.

\Rightarrow represents homogenously Granger causes

The findings indicate several significant causal relationships: Bidirectional causation exists between investment in transport infrastructure and industrial sector productivity, transport-induced labour accessibility and industrial sector productivity, also investment in transport infrastructure and transport-induced labour accessibility in the ECOWAS Region. These results underscore interrelationships among investment in transport infrastructure, labour accessibility, and industrial sector productivity within ECOWAS, providing insights into the dynamic interactions shaping economic development in the region.

5. Discussion and Conclusion

Based on the results, the productivity of the industrial sector was positively impacted and significantly affected by the investment in

transport infrastructure and defence budget. Transport-induced labour accessibility had negative and significant effects on industrial sector productivity while credit to the private sector and labour force exhibited negative and insignificant effects on industrial productivity in the ECOWAS. The relationships observed between these variables are consistent across both short-run and long-run periods. This was in line with the study conducted by Piyapong (2020), Demetriades, and Mamuneas (2000). Bimba et al. (2020) Castaeda and Shemesh (2000); Stephen et al. (2019) Leopoldo and Daniel (2013) several developed and developing countries investigated found that investment in transport infrastructure and transport-induced labour accessibility has demonstrated beneficial and significant effects on industrial productivity.

Considering the empirical findings of this study, several conclusions were drawn. Firstly, it was concluded that low percentage of investment in transport infrastructure significantly impeded industrial growth and efficiency, making it a critical area for economic development strategies because investment in transport infrastructure is a cornerstone for boosting industrial productivity in ECOWAS. It provides the necessary foundation for efficient supply chains, reduces costs, attracts investment, fosters economic growth, and facilitates regional integration. Secondly, the study also concluded that transport-induced labour accessibility can undermine the potential growth capacity of the industrial sector because of inaccessibility of skilled labour to industrial sector productivity. This suggests

that while investments in transportation can yield substantial returns through increased productivity, economic growth, and sustainable development, there are potential drawbacks that need to be addressed. In light of these conclusions, the study proposes the following recommendations: There should be a focus on directing more investment towards the development of new transport infrastructure to complement existing ones. ECOWAS leaders should invest in the expansion, modernization, and maintenance of road networks to improve connectivity between urban and rural areas. Develop and expand mass transit systems, such as buses and commuter trains, to provide affordable and efficient transportation options for the workforce.

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